Charcoal the Cause of a Fish Kill?

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ABSTRACT

Zitko, V., and L.E. Burridge. 1999. Charcoal the cause of a fish kill? Can. Manuscr. Rep. Fish. Aquat. Sci. 2503: iii + 4 p.

Raising salmonids in facilities dependent on municipal water supplies requires the use of dechlorinators to remove chlorine from the water. At the Biological Station in St. Andrews charcoal dechlorinators are used to perform this task. The capacity of charcoal to remove chlorine diminishes with time and usage, necessitating its replacement with fresh charcoal. After one such charcoal change in our facility several hundred juvenile Atlantic salmon died. This report describes the results of tests conducted to determine the cause of this fish kill. New charcoal was efficient in removing organics from the incoming water. The concentration of copper in the water was 0.18 mg/L compared to 0.03 mg/L measured prior to the addition of the new charcoal. It remains unclear what killed the fish although the new charcoal appears to have been involved. It is hoped that this report may alert other institutions to the possibility that fresh charcoal may contain impurities that could be lethal to fish.

RÉSUMÉ

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L'élevage de salmonidés dans des installations alimentées par un aqueduc municipal nécessite l'utilisation d'agents de déchloration de l'eau. À la Station biologique de St. Andrews, on utilise pour ce faire des agents de déchloration au charbon. Or, la capacité du charbon de retirer le chlore de l'eau diminue avec le temps et l'usage, d'où le besoin de remplacer périodiquement le charbon. Tout de suite après un tel changement du stock de charbon à notre installation, plusieurs centaines de saumons atlantiques juvéniles sont morts. Le présent rapport décrit les résultats de tests effectués pour déterminer la cause de cette mortalité massive de poisson. Le nouveau charbon a été efficace, c'est-à-dire qu'il a retiré les substances organiques de l'eau d'arrivée. Par contre, la concentration de cuivre dans l'eau était de 0,18 mg / L comparativement à 0,03 mg / L avant l'ajout du nouveau charbon. La cause exacte de la mortalité de ces poissons demeure incertaine, mais il semble que le nouveau charbon soit en cause. Nous espérons que ce rapport mettra en garde d'autres établissements contre la possibilité que du charbon frais peut contenir des impuretés pouvant s'avérer mortelles pour les poissons.

Research into the freshwater stages of Atlantic salmon conducted at the Biological Station in St. Andrews, New Brunswick depends on a reliable supply of high quality fresh water. The source of fresh water for the Biological Station is a lake that also serves as the municipal water supply for the Town of St. Andrews. The water is very soft (total hardness 14 mg/L as calcium carbonate) and contains humic/fulvic acids at about 4 mg/L. At the lake, the water passes through coarse screens and is chlorinated.

Salmonids are very sensitive to chlorine and the water must be dechlorinated prior to entering fish tanks. The 30-min LC50 of chlorine for juvenile coho salmon (at 10°C) is 0.56 mg/L (Spehar et al. 1979). The recommended maximum concentration of chlorine in salmon culture facilities is 0.03 mg/L (Piper et al. 1982). It is essential that chlorine levels are low and dechlorination methods are operating optimally. Dechlorination by activated carbon (charcoal) filters is a common method of removing chlorine (see, for example Giles and Danell, 1983). At the Biological Station, charcoal-filled dechlorinators (Ecowater Industrial Systems 500 North Venty Parkway, Middletown, OH 45042, USA, Model cc30 dechlorinator, filled with approximately 300 kg of granulated charcoal) are used to remove chlorine.

There is no convenient way to monitor the capability of the dechlorinator to remove free chlorine. Total chlorine is monitored at the dechlorinator outflow and the only defense against poor dechlorination is an alarm set at 0.07 mg/L of total chlorine. Free chlorine is seldom detectable at the dechlorinator intake and the concentration of total chlorine, monitored at the dechlorinator outflow is mostly 0.005 mg/L or less. The dechlorinator serves as an 'insurance' against chlorine 'spikes', which may occur occasionally. The dechlorinator is backwashed periodically, usually at least once a month.

Standard operating procedures call for a yearly replacement of charcoal (recharging). In August of 1998 charcoal was replaced in each of the two dechlorinators at the Biological Station over a 3-d period. The new charcoal was flushed for several hours prior to being placed 'on line'. Surprisingly, all juvenile Atlantic salmon held in the treated water died within 2 d of the first dechlorinator being placed in service and within hours of the second.

The loss of fish coincident with the change of charcoal in the dechlorinators led us to investigate the effluent water from the dechlorinators for clues as to what may have killed the fish. Of interest was the observation that the water entering the tank appeared different from normal. The water appeared slightly cloudy, although it was still easy to see the bottom of the tank. Ultraviolet (UV) spectra of the water showed the new batch of charcoal was very effective in removing organics from water (Fig.1, new C). Metal analyses showed elevated copper levels soon after the second dechlorinator was placed in service (0.18 mg/L compared to 0.03 mg/L in a sample collected earlier the same day - prior to bringing the dechlorinator into service). This concentration is considerably higher than the 'incipient lethal level' for juvenile Atlantic salmon of 0.048 mg/L (Sprague 1964), the concentration recommended for hatcheries (0.03 mg/L), and is equal to the 96 h LC50 for copper and rainbow trout (Spehar et al. 1979). These salmon were exposed to effluent from the second dechlorinator for a matter of several hours during which time copper concentrations may have been considerably higher. It remains unclear if copper caused the observed mortality. No analyses for organics were performed.

It was of interest to monitor the status of the charcoal by the determination of (UV) spectra of water at the intake and at the outflow of the dechlorinator. The spectra are fairly featureless with the light absorbance increasing monotonously with decreasing wavelength. UV spectra of the outflowing water appear parallel to those of the incoming water, but the absorbances are somewhat lower (Fig. 1). This decrease is caused by a 'filtration' effect of the dechlorinator and by adsorption of some humic/fulvic acids. The absorbance difference increases with decreasing wavelength (Fig.2).

The adsorption capacity of the charcoal decreases gradually, as the surface becomes saturated. This decrease was monitored for about 3 mo. As can be seen from Fig.3, during this period the adsorptive capacity of the charcoal decreased to 'normal' level. Backwashing of the dechlorinator occasionally caused a slight increase in the capacity (see Fig. 3, 'spikes'). Water flow was only about 20 L/min during this period. Because of operational circumstances, no fish were present in the treated water during these 3 mo. Consequently, it is not known at what point before reaching the background

absorbance difference, the dechlorinated water ceases to be toxic to juvenile Atlantic salmon, if it ever was the cause of the kill.

The described event might have been an isolated incident with an unknown cause, although it seems clear the new charcoal was involved. The fact that the same lot of charcoal was used to recharge both dechorinators argues against individual bags being contaminated. This particular lot may have been contaminated and the fish may have been affected after the first recharged dechlorinator was put in service. The contaminant effect may have become lethal when the second dechlorinator was added. While the cause of this fish kill will probably remain a mystery, this incident underlines the need to pay close attention to charcoal dechlorinators, particularly when switching to a new batch of charcoal.

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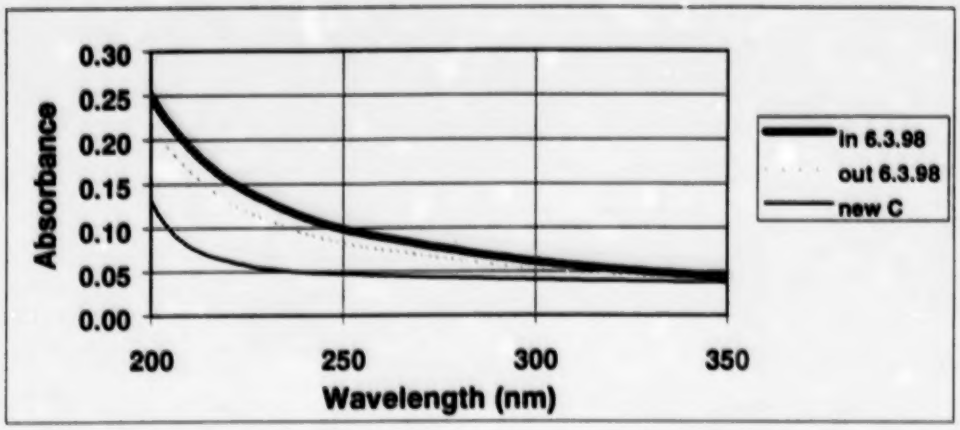

Fig.1 Ultraviolet (UV) spectra of incoming and 'dechlorinated' water. A kill of Atlantic salmon parr occurred after 2 d in water dechlorinated by new charcoal.

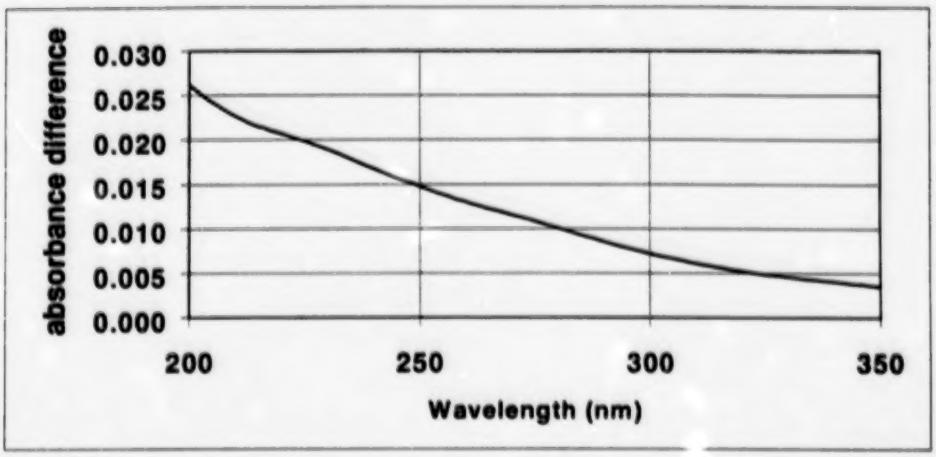

Fig.2 A difference spectrum, difference of absorbance between incoming water and dechlorinated water.

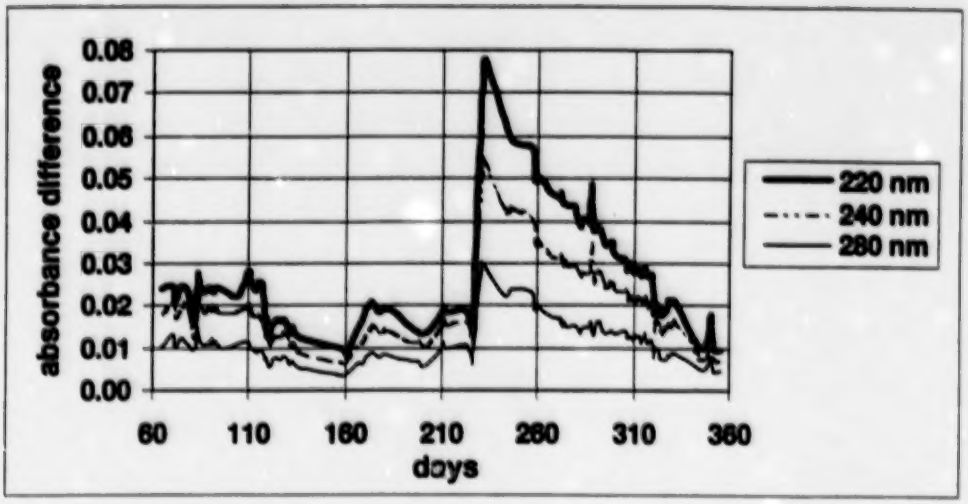

Fig. 3. Changes in the difference spectra (absorbance of incoming water minus treated water) during most of a year. A large increase in day 225 is caused by a new batch of charcoal. A kill of Atlantic salmon parr occurred 2 d later.